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HAND-HELD COMPUTING DEVICES AND LARGE KNOWLEDGE BASES

Capraro Technologies, Inc.

Gerard T. Capraro

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This report documents the demonstration of how hand-held computing devices can bring information to the warfighter no matter where he or she is located. A demonstration was developed using commercially available beta software from the world wide web technology base. The demonstration allows a warfighter to upload and query heterogeneous databases located anywhere on the internet using a hand-held computing device. Numerous hand-held devices were evaluated and four were chosen for demonstration. The demonstration was performed using hardwired telephone and cellular telephone technology. A proposed architecture is presented that stresses intelligent agent, knowledge bases, and integrated heterogeneous database technologies while stressing alter ego assistants that will harness the world wide web network computing power for the warfighter.

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Abstract

This report documents the demonstration of how hand-held computing devices can bring information to the war fighter no matter where he or she is located. A demonstration is developed using commercially available beta software from the world wide web technology base. The demonstration allows a war fighter to upload and query heterogeneous databases located anywhere on the Internet using a hand-held computing device. Numerous hand-held devices were evaluated and four were chosen for demonstration. The demonstration was performed using hardwired telephone and cellular telephone technology. A proposed architecture is presented that stresses intelligent agent, knowledge bases, and integrated heterogeneous database technologies while stressing alter ego assistants that will harness the world wide web network computing power for the war fighter.

1.0 Introduction

Accurate and timely data is a corporate resource. Inaccurate or untimely data is a corporate expense. The military lacks the ability to provide timely, accurate data and information to its war fighters because the war fighter does not have access to computer technology in the combat environment. The Department of Defense is data rich and information poor. War fighters in many situations must labor over an inordinate amount of data before obtaining data or information they require.

Rome Laboratory and now the USAF Research Laboratory's Information Directorate has been investigating solutions to these problems, through the integration of large databases and knowledge bases. They have pursued numerous efforts by many experienced researchers. It is now time to provide access to this wealth of data and information from anywhere in the world.

Military personnel need to communicate with superiors and command centers. Over the years these communications have been primarily audio. However, with advances in computing and communications technologies, it is possible to exchange both audio and visual communications with anyone using laptop computers, personal digital assistants, and consumer electronics devices. One can stay in touch with his/her e-mail, send or receive faxes, access applications on a home computer, and query knowledge and databases anywhere in the world. He/she can have access to very large amounts of data and information in any form (i.e. voice, graphics, and video).

The objective of this effort was to perform a proof of feasibility demonstration by remotely accessing disparate databases in a seamless manner via the Internet using a hand-held computing device (HCD). A demonstration was performed by using both a cellular phone and telephone connection to the world wide web (www). This demonstration provided not only the proof that this concept is feasible but it has also uncovered gaps in the technology that need attention before a realistic system can be fielded.

Universal goals are:

- To provide field acquisition and retrieval of quality data in a timely manner.
- To upload, download, and store multimedia data, i.e. pictures, sound, and video.

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- To search distributed databases and knowledge bases in "real time" and in a secure mode.
- To upload, download, store, fuse and present sensor data in a meaningful and intuitive manner.

This effort provides a demonstration of a necessary portion of the foundation required to meet these goals.

The next section, Section 2, provides a description of and motivation for this effort. Section 3 discusses the HCDs purchased at the beginning and end of the effort. Section 4 describes the demonstration performed. Section 5 documents preliminary findings and a view of the next generation of network technology to support HCDs and their processing needs.

2.0 Effort Description

Legacy databases exist throughout the US Air Force. These databases were costly to develop and are costly to maintain. They are the backbone to many military decision processes utilized throughout the US Air Force, during both peace and conflict. The Air Force has pursued research to integrate these databases in such a manner that these databases appear to the user to be on the same machine, and using the same database management system (DBMS). This capability allows the individual databases to continue to be developed and maintained in their current consistent manner and yet allow many users to integrate their data and reap the benefits of this synergy.

The development of the browser technology, the Internet, and Intranet systems provide the capability of integrating these disparate databases with the same user interface. This capability is independent and transparent of the DBMS and, to a certain extent, its resident machine. This allows a user to interact with these integrated databases over a network as if they were a homogeneous database.

This effort investigated a vendor neutral approach. An integrated approach was performed, using Java and Hypertext Mark Up Language (HTML) as the languages for building the user front-end and Java's database connectivity (JDBC) for accessing different DBMSs was used. Java programs can run on a Java virtual machine within a browser or as a native installation.

The motivation for this effort and the use of HCDs was to bring the capability of this technology to the war fighter. There is no reason why the power of a network of computers cannot ultimately be brought to the battlefield. As the telephone can be used by anyone speaking any language, a HCD can provide anyone access to data and information. In this manner, an HCD can be used by a physician or medic that scans an injured war fighter's dog tag to gain access to the person's medical records, X-rays, MRIs, etc. They can also upload data related to current injuries sustained by the fighter. This same HCD can be used by the commander of the unit to obtain data related to mission planning, staffing, and reconnaissance.

There are many issues that need to be answered before today's HCDs are deployed to every war fighter. This effort's hope was to show the capability of the Internet to handle one aspect of the above scenario: the ability to access two different databases located on two different computer nodes on the Internet. The demonstration should allow the

user to upload data and retrieve data from the databases such that the DBMS "appears" resident on the HCD. The user interface to the database must be simple and intuitive. The object was to make it easy to understand, easy to use, and as keyboard independent as possible.

The advent of the modern day computer, the Internet, and arcade games have conditioned today's war fighter to be at ease with computer technology. However, war fighters are not computer programmers and there are no database administrators in the field to help them formulate a new query that wasn't pre-programmed. The approach taken was based on a simple database application for demonstration purposes. By keeping the database application simple, evaluating the underlying technology was not clouded by the complexity of the application chosen.

The experiment we chose is illustrated in Figure 1. Once logged into the network via a phone line or cellular connection the user is able to either retrieve data from or submit data to one or both databases (A or B) located on two different nodes on the Internet. The user sees the integrated view of the data. The host node through which the user accesses the Internet recognizes the user and sends HTML pages. The user can then navigate around the page, enter parameters, submit queries and view query results. These queries can be used to view, update, append or delete records. All of the data processing is done on the nodes within the network. The HCD is providing the connection to the network, the protocols for communication, the display of the HTML pages, and the capturing of the data and controls from the user.

Goal of Effort - Demonstration

DBMS (A) DBMS (B)

Host Machine
Web Page
DBMS (Main)

Cellular Phone Connection

PDA Query (A U B)
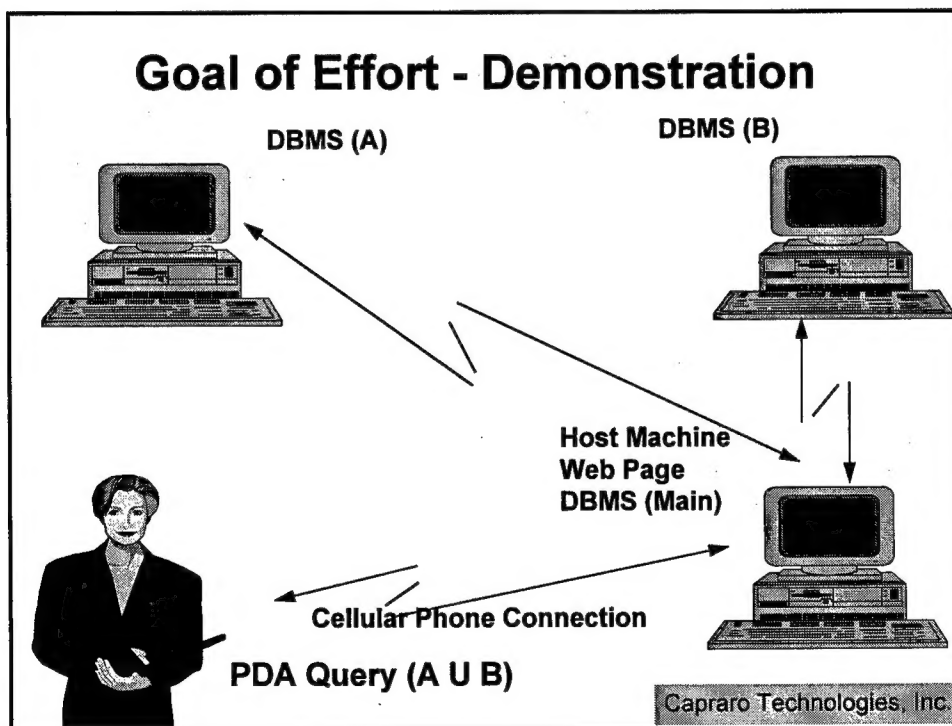
Capraro Technologies, Inc.

Figure 1. Demonstration Depiction

The host machine contains the software to communicate with the HCD and the two nodes contain DBMS A and B. It also contains a DBMS with a meta database of the data dictionaries/directories of the databases located within DBMS A and B and the integrated view of these two databases. When the user wishes to query the integrated database, the software running on the host machine recognizes the query and spawns one or more queries to A and/or B, obtains their results, joins them if needed, and performs a projection and translation to comply with the user's integrated view. A similar process is performed if the user changes the contents of the database or adds new occurrances to his/her database.

3.0 Hand-Held Computing Devices

When this effort began, CTI purchased four HCDs, two of one kind and two of another. CTI has been tracking HCDs ever since the first Apple Newton MessagePad was available and are aware of the dynamics in the industry. To leverage resources CTI purchased two HCDs at the beginning of the effort and re-evaluated the technology and purchased the second two at the end of the effort. CTI evaluated the best of them based upon the attributes shown in Figure 2.

Processor speed,	Operating system,	Amount of RAM,
Amount of storage,	Expandability,	Overall size,
Screen size and type,	Methods for entering data,	Keyboard type and availability,
Battery power,	Modem speeds,	Weight,
Hardness or ruggedization,	Connectivity to other machines,	Communications,
Software, and	Price.	

Figure 2. HCD Evaluation Attributes

Given the results of this evaluation and the contents of technical articles, Apple's Newton Message Pad 2000 and Philips' Velo 1 were chosen. At the end of the effort CTI re-evaluated the technology and purchased Philips' Velo 500 and Hitachi's HPW - 200EC. A list of the set of devices evaluated are presented in Figure 3. (Note the data in Figure 3 were obtained in June 1998.) The technology has progressed; processing power has increased, color is now available, memory has increased, better operating systems are available, and HCD prices are coming down and their value is going up. Some HCDs connect to the web, have browser capability, have voice input capability, and they will soon be able to execute Java outside of a browser.

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Today's Hand-Held Computing Devices - A Comparison-- All Use Windows CE 2.0											
Co.	Model	RAM	Speed	Screen	Modem	PCMCIA Slots	Battery Life (hrs)	Approx Price			
Hand-held PC's											
Casio	Cassiopeia A-20	16M	80 MHz	4 gray	No	1	10	$600			
Compaq	C-810	24M	75 MHz	4 gray	33.6 kbps	1	15	$600			
LG	Phenom Ultra	28M	75 MHz	256 colors	33.6 kbps	1	10	$900	VGA out port for monitor connections		
NEC	MobilePro 750c	32M	78 MHz	256 colors	33.6 kbps	1	7	$900			
Phillips	Velo 500	40M	75 MHz	16 gray	28.8 kbps	1	13	$850	includes pc card module		
Sharp	Mobilon HC-4500	32M	75 MHz	256 colors	33.6 kbps	1	3	$1,000			
Hitachi	HPW-200EC	44M	100 MHz	256 colors	33.6 kbps	1	rated 10	$1,200	VGA out port for monitor connections		
H-P	620-LX	26M +	75 MHz	256 colors	none	1	rated 10	$1,000			
Novatel	Contact	48M	80 MHz	4 gray	14.4 kbps	1	rated 8		includes a wireless modem		
		All require a cellular PCMCIA modem : 56K modem						$155			
Any of these machines can use a flash memory card, but not with a cellular modem											
All require a cellular modem cable								?			
All screens are 640 x 240 pixels											
Palm Sized PC's											
Casio	Cassiopeia E-10	28M	66 MHz	4 Gray	19.2 kbps	0	rated 25	$700			
Everex	Freestyle	16M	66 MHz	4 Gray	33.6 kbps	0	rated 20	$700			
Phillips	Nino	16M	75 MHz	16 gray	19.2 kbps	0	rated 10	$800			
		The above screens are 240 x 320 pixels									
		The above will not accept a cellular PCMCIA modem.									

		Dimensions	Weight (oz)								
Casio	Cassiopeia A-20	3.7 x 7.25 x 1	15.2								
Compaq	C-810	3.9 x 7.3 x 1.3	13.9								
LG	Phenom Ultra	4.3 x 7.7 x 1.1	16.9								
NEC	MobilePro 750c	5.4 x 9.6 x 1.2	28.8								
Phillips	Velo 500	3.75 x 6.75 x 1	15	Add weight and depth for the pcmcia card module							
Sharp	Mobilon HC-4500	3.8 x 7.3 x 1.2	17.6								
Hitachi	HPW-200EC	1.3 x 10 x 5.2	28.9								
H-P	620-LX	7.8 x 4.1 x 1.4	20.6								
Novatel	Contact	1.2 x 7.6 x 4.7	22.4								
Casio	Cassiopeia E-10	.07 x 3.2 x 4.9	5.5								
Everex	Freestyle	.07 x 3.2 x 4.8	5.3								
Phillips	Nino	.08 x 3.4 x 5.3	7.3								

Figure 3. Hand-Held Computing Devices

4.0 Demonstration

The demonstration chosen uses very simple database schemas. However, the goal of the demonstration was to show the technology's potential. Two databases were defined, each containing one relation. They are both defined and resident on two different relational DBMSs on two different computers accessible via the world wide web. The HCD calls a node on the internet, i.e. an internet service provider (ISP), which then provides a connection to the computer containing a relational DBMS that contains a meta database defining the data dictionary of the two relations stored on the other two machines. This machine contains the Java code that generates the HTML pages for the HCD and communicates with the user to generate the queries to the other two DBMSs.

Each database contains a single relation. The schema for A is the Employee Address relation, and For B is the Employee Department relation. These relations are defined below.

EmployeeAddress
EmployeeID
FirstName
LastName
SpouseFirstName
StreetAddress
City
StateOrProvince
PostalCode
HomePhone

EmployeeDepartment
EmployeeID
SocialSecurityNumber
DepartmentNumber

Here are sample data for each database:

Sample Employee Address relations.

EmployeeID	FirstName	LastName	SpouseFirstName	StreetAddress
150	John	Jones	Rose	State St.
160	Phil	Jones	Lisa	Robert Rd.

City	StateOrProvince	PostalCode	HomePhone
Rome	NY	13440	315 336-4968
Rome	NY	13440	315 336-4987

Sample Employee Department relations.

EmployeeID	SocialSecurityNumber	DepartmentNumber
150	786543332	01
160	537675555	05
090	352136478	05

To link data between the two relations, a join is performed between the two relations on their common primary key, EmployeeID. The Employee Department relation and its occurrences comprise Database A and Employee Department relation and its occurrences comprise Database B. The schemas of both databases and their internet addresses are stored on the Host Machine as shown in Figure 1.

Our demonstration consists of a select query on the joining of the two databases related to an employee's last name and their resident city and a method for the user to enter a subset of the attributes for a new employee entering the company. A screen dump of the first screen is shown in Figure 4.
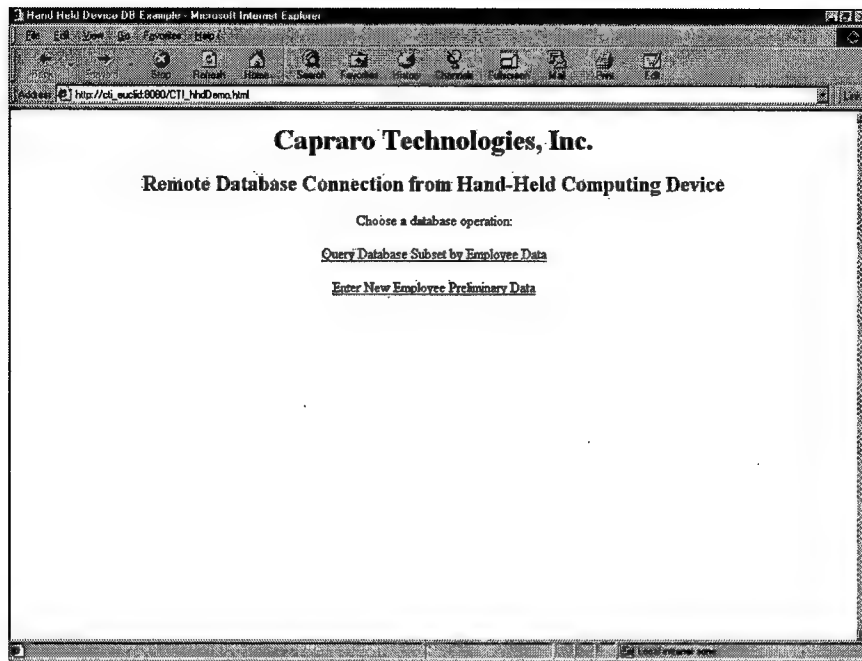
Figure 4. HCD Main Menu

The screens shown in Figures 5 and 6 allow the user to create a query to the databases. From the first pull-down box the user selects either LastName, City , SocialSecurityNumber or EmployeeID from the list. The user then chooses a comparison from the second pull-down box, either equality (=), or if the field selected is numeric, greater than, (>) or less than (<) may be selected. The next box accepts the value for this comparison. The user can then add additional lines to the query, and connect these lines by a logical AND or OR. A SQL query statement is generated from these lines and submitted to the database.

Figure 5. Database Query

Figure 6. Database Query Result

The following screen dump, Figure 7, illustrates how a user can easily insert new data within the database. If the user makes an error, the mistake can be nulled by clicking the "Reset" button. When the input is correct the user the "Submit" button.
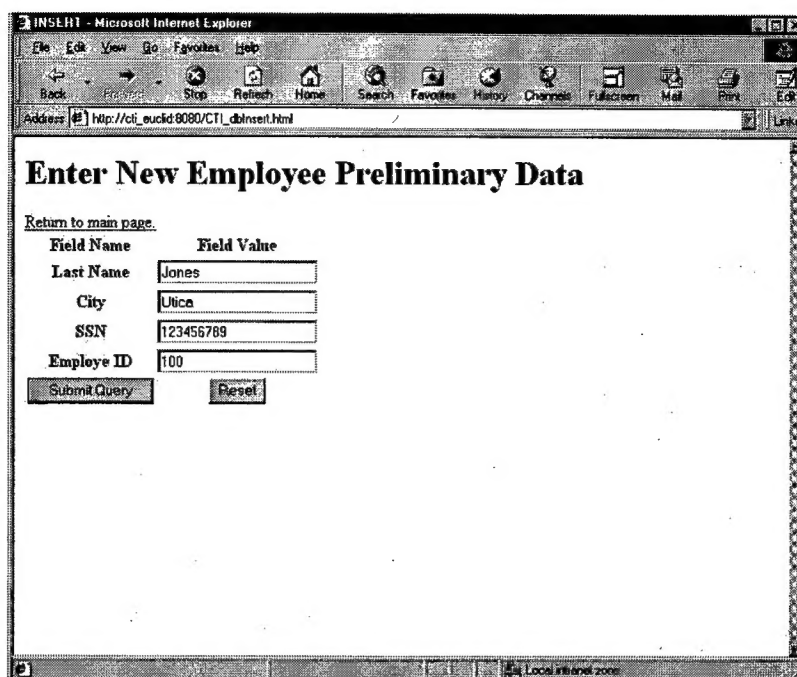
Figure 7. Database Update

These procedures are easy to understand, are conducive to "point and click", and minimize the amount of data the user has to type, or on some HCDs, write. This simplicity minimizes errors and the time required for the user to submit requests to the system.

5.0 Preliminary Findings and New Network Technology

The major objective for this effort was to evaluate HCDs and their ability to bring data and information to the war fighter in the field. The preliminary findings indicate that these devices have great potential as a method to bring the data and information that are available within a Government Internet to a person located almost anywhere. As these devices add more processing power and memory, some or all of the processing performed on the network can be downloaded to the devices. The Network, Browser, and Java (NBJ) paradigm is ideal for integrating these devices within the PC, workstation, and mainframe world. The demonstration above was performed using some Beta software tools. As this effort progressed these software tools have become commercially available. It is only a short time until these devices will appear throughout the world similar to the cellular phone or calculator. The mingling of phone technology, computing, e-mail, television, and eventually video collaboration is only time and bandwidth restrictive, given the rate in which processing speed, communications, and memory technology is advancing.

The NBJ paradigm will make the HCD "everyone's" machine of choice for remote computing. These devices are application independent. They can accept handwriting

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as input and/or a keyboard. Some will accept scanning devices for inputting bar codes. They can display map data and provide location coordinates with connections to a Global Positioning Satellite (GPS) system. The NBJ paradigm allows the user to retrieve the latest in software updates each time one logs into the system. This technology will allow the military to deploy troops and reduce the "footprint" of their deployment by reducing the amount of documents required in the battle field. The war fighter can always retrieve the latest information from the network rather than transporting maps, books, manuals, etc. into the field.

There are also some enhancements that are needed. Most of these devices are not "hardened" or rugged enough to withstand the varied environments the military requires. It would be beneficial if there was a standard way to use these devices to display data from different and varied sensors. Speech intelligibility would be useful in some situations. It would be beneficial in some situations if they had a larger screen with more resolution, that could be folded away when not in use. Some people would like a larger keyboard that also could be folded away.

Accessing very large databases, information sources, and knowledge bases resident on a network will require more advanced software. Integration of these data, information, and knowledge bases is not enough, intelligent based tools to help the user is required. Each user needs an intelligent personal assistant, a person's "Alter Ego," that can be tailored on the fly.

HCD users will require various forms of help that will reside on the network.

- The help must be all-inclusive and easy to understand.
- The processing must be transparent to the user. Intelligent software will diagnose and solve problems without interrupting the user's processing.
- Users will require the ability to utilize and manage their database. This ability includes an ad hoc query capability, and methods to add and/or delete attributes.
- Users will need to understand the results of their queries and the performance of knowledge bases. The intelligent architecture must be able to explain its answers.
- The intelligent architecture must have the ability to drill down through varied data sources, mine databases, and perform knowledge discovery.

Figure 8 shows an example architecture that illustrates the integration of multiple data sources (in this case, resident databases in DBMSs) and providing results to the war fighter.
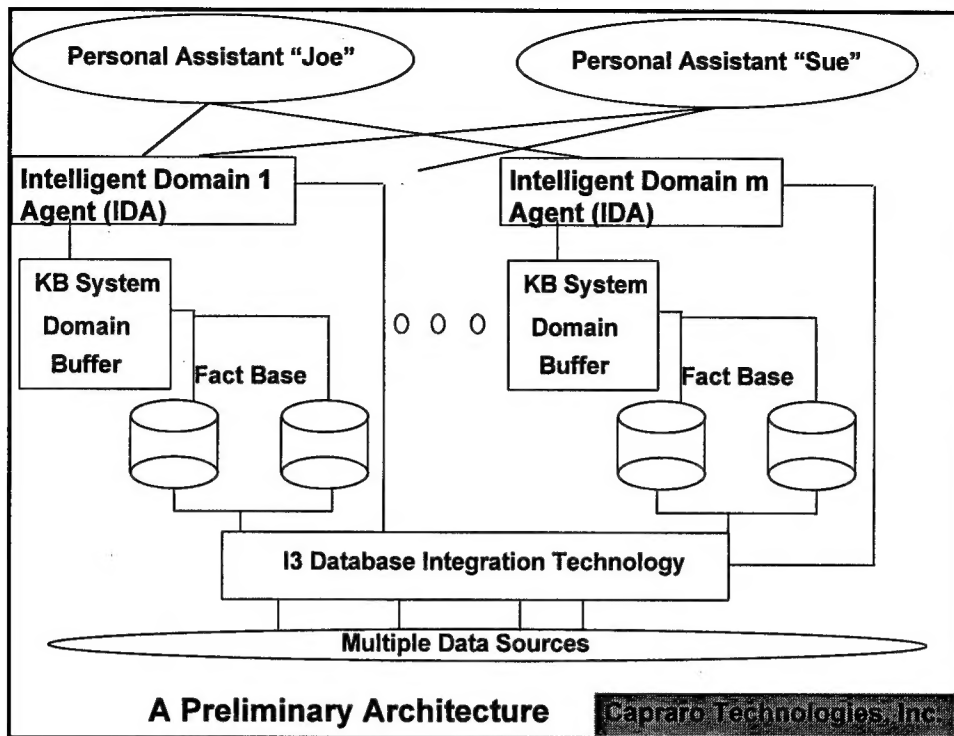
Figure 8. A Preliminary Architecture

The architecture will have intelligent software that fulfill the needs for the individual war fighter. If a request is submitted for instance of the network from a HCD then the alter ego or personal assistant will process the request differently than if the war fighter submitted the same request from a workstation with a T1 communications line. The system will assess the complexity of the request, determine its time required to perform the task, and then download the result for presentation to the user in a customized format for the computing device and available bandwidth. The system may respond to the user with an estimate of the time to respond and with a method of response, rather than just responding if the user is entering the system from a different device or bandwidth than normal. It may suggest that the user be alarmed when it is complete or have the results displayed in a graph rather than communicate the raw data. It may suggest that the raw data be sent to an e-mail address and accessed later from a more powerful computing device. The personal assistant will also optimize performance based upon the processing performed on the net, on the HCD, and the amount of bandwidth, processing speed and memory available on all the processing nodes involved.

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